

Interregional Project for the Development of Fisheries
in the Western Central Atlantic

Proceedings of the
Working Group on Shrimp Fisheries of the
Northeastern South America
Panama City, Panama, 23-27 April 1979
Contributions

**A Technique to Obtain Information for
Shrimp Management in the
Western Central Atlantic Ocean**

by

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fishery off the Guiana-Brazil continental shelf of South America in 1959. Annual landings reached about 8 000 t by 1961 and between 11 and 14 000 t.

Distribution of shrimp is generally continuous along the South America coast from Brazil to Panama, specific stocks are well defined. At present unit fisheries are generally as- signed to specific Fisheries. Specific information relating to biological characteristics are presently unavailable.

Resource assessment studies have been restricted to general catch and fishing effort data from the commercial fishery surveys (Jones and Dragovich, 1977); Wise, 1976; Naidu and Dragovich, Jones, and Boucher (1980). The specific parameters, growth, mortality, and migration, have not been determined nor has the distribution of juveniles. These data have been used to develop sophisticated yield models. Herein the National Service Gulf of Mexico Shrimp Research Programme is presented for a research programme to provide technical information for fisheries management for the Guiana-Brazil area.

Research in the Gulf of Mexico

and

Mexico is the major U.S.A. shrimp fishery. Approximately 100 000 t of shrimp landed is caught from the Gulf. The total value of shrimp landed is estimated to have increased from 61 000 t in 1961 to 127 000 t in 1977. Brown shrimp, Penaeus aztecus, accounts for 53 percent of the landings, white shrimp, P. setiferus, for 26 percent, and pink shrimp, P. duorarum, for 15 percent.

Shrimp research was initiated by the Gulf coastal station at Galveston Laboratory of the Bureau of Commercial Fisheries (now National Marine Fisheries Service NMFS) in the late fifties. The research has continued since, to provide information for management of the fishery. Each state's research programme was funded separately. The programmes were tailored to each state's needs and fishing effort, and some economic information to the states. In the early sixties, high seas surveys by the NMFS provided information on the life history of the major shrimp stocks. These findings were used by Lindner and Cook (1970), Cook and Lindner (1970) and Lindner (1970). In the late sixties that research was significant.

The U.S. extended fisheries jurisdiction from the edge of the continental shelf waters offshore to 200 mi. Regional management councils have been established and charged with developing management plans for all of the fisheries.

U.S. fishery resources within the conservation zone excluding tuna. As a result of this action, emphasis was again placed on providing scientific information for the management of the shrimp resources. This accelerated activity was exemplified by the role of the NMFS Southeast Fisheries Center's Galveston Laboratory in expansion of shrimp research to provide basic scientific information to the appropriate management entities.

Brown, pink, and white shrimp are distributed throughout the northern and western Gulf of Mexico (Osborn, Maghan, and Drummond (1969)). The center of abundance of brown shrimp is found off Texas, white shrimp off Louisiana, and pink shrimp off southern Florida with highest concentrations off Dry Tortugas. The number of stocks included nor their boundaries have as yet been documented.

Initial mark-recapture experiments indicated that white shrimp resources are continuous from the northern Gulf and into Mexico (Lindner and Anderson, 1956), with records of marked white shrimp moving across the U.S.-Mexican border. There appears to be two separate stocks of pink shrimp, one on the Campeche Bank off Mexico and the other off South Florida on the Tortugas and Sanibel grounds. Although shrimp resources have been investigated for the last two decades in the Gulf of Mexico, information required to identify and document stock boundaries is not yet available.

Christmas and Etzold, (1977), reviewed the available fishery data and summarized information on growth, mortality, and length-weight relationships for the major shrimp stocks in the Gulf of Mexico. The growth of pink shrimp has been described off Tortugas (Berry, 1965), brown shrimp off Texas (Parrack, 1978) and off Tampico (Chavez, 1974), and white shrimp off Louisiana and Texas (Lindner and Anderson, 1956) (Klima, 1974). These studies indicate that shrimp growth rate differences do exist between seasons and locations and that those differences are large. Results of several investigations of mortality rates differ greatly indicating probable death rate variations of great magnitude (Table 4.5.I).

Table 4.5.1 Weekly Instantaneous Mortality Rates, F, M, and Z, for Three Commercially Important Shrimp Species (Sexes Combined) (from Christmas and Etzold 1977)

<u>Shrimp Species</u>	<u>Fishing Mortality</u>	<u>Natural Mortality</u>	<u>Total Mortality</u>
	F	M	Z
Brown	0.06	0.21	0.27
	.020-0.315	---	---
	---	---	0.993-1.243
	0.206	0.364	0.571
White	---	---	0.46
	0.06-0.19	0.08	0.14-0.27
	0.104-0.131	0.041-0.121	0.164-0.226
Pink	0.09	0.27	---
	0.96	0.55	0.76-1.51
	0.160-0.227	0.024-0.061	0.22-0.27
	0.03-0.07	0.08-0.11	0.11-0.18
	0.09	0.02	0.11
	0.337	0.280	0.612
	---	---	0.317-0.350

Each stock may be subjected to extremely different rates of exploitation and to vastly different rates of natural mortality at different times. In general, present estimates of growth and mortality are not extensive enough to develop realistic yield models.

2.2 Objectives

The goal of the Present National Marine Fisheries Service Research Programme is to provide scientific information for management to the Regional Fishery Management Councils. Four major identified research areas are: (1) delineate stocks in the Gulf of Mexico, (2) obtain complete catch statistics, (3) predict biological and economic yield under various long-term fishing strategies, (4) develop quantitative estimates of current surplus production which account for environmental influences on recruitment abundances.

2.3 Surplus Production Model

Klima (1980) described the current Gulf of Mexico shrimp statistical survey initiated in 1956. Current outputs from this survey are published reports of ex-vessel shrimp prices and summaries of annual and monthly shrimp landings and effort statistics. Unfortunately, the amounts of shrimp caught and discarded at sea or that are sold but not landed at fish houses are unmeasured. In the northern Gulf of Mexico vessels catch either brown or white shrimp or both on a given trip. Landings and fishing effort information recorded from interviews of fishermen and from fish buying houses is being analysed by individual trip to standardize fishing effort directed at each species. These adjusted data will then be used to develop a preliminary model of the relation between fishing intensity and surplus production for each shrimp species. Data from this statistical survey collected over the past 20 years have

already been used (Klima and Parrack, 1977) to develop a preliminary surplus production model of the total shrimp resource in the northern Gulf of Mexico. In addition, the Fishery Management Councils have utilized these basic data to develop the shrimp fishery management plan.

2.4 Mark-Recapture Experiments

To obtain information on stock boundaries, migration, growth and mortality, a major mark and recapture study was initiated in 1977 and continues through 1979.

The objectives of this research programme are (1) to define the cohort and environmentally specific growth of shrimp from a single estuarine system, (2) to determine the extent and direction of shrimp migration, (3) to estimate mortality of brown and white shrimp associated with specific estuaries, and (4) to provide specific distributional information on the transboundary brown shrimp resource which occurs from Corpus Christi, Texas, to Tampico, Mexico.

In past shrimp marking experiments, several different marks have been used, including biological dye and Petersen disk tags. Dyes cannot be detected after about three to four months and the Petersen disk tag, even when scaled down to a small size, is known to cause extremely high mortalities when placed in juvenile shrimp. Marullo and Emiliani, 1976, perfected a polyethylene streamer tag for our experiments. The numbered ribbons are 4-6 mil thick, 95 mm long, and 3 mm wide. They are placed through the tail of the shrimp so that half of the ribbon protrudes from each side.

Over 36 000 juvenile white shrimp were tagged and released from July through October 1977 in Caillou Lake area of southern Louisiana. Concurrently, 8 388 white shrimp were tagged and released offshore of this estuary from August through September. Approximately 9.3 percent of those released were recovered from July through December 1977 (Table 4.5.2). This recovery rate is high in comparison to previous mark and recapture experiments conducted in the Gulf of Mexico (Clark et al., 1974). We believe that the new monetary incentive system for return of recaptured shrimp contributed to the high recovery rate.

Table 4.5.2 Number of tagged white shrimp released in Louisiana waters from July to December 1977 and number and percent recovered

Location	Released	Recovered	Percent
Inshore	36 639	3 807	10.4
Offshore	8 336	383	4.6
Total	44 975	4 190	9.3

Several different forms of incentive systems have been used in past mark-recapture experiments to motivate fishermen and processors to return marked shrimp. In past instances, awards of US\$ 0.50 to US\$ 5.00 have been offered for returned shrimp, although the standard reward was US\$ 2.00 in the northern Gulf. Some shrimp fishermen stated, however, that it was not worth their time to return shrimp for only US\$ 2.00. Conversely, many fishermen return shrimp without monetary reward. To increase the return rate of recaptured shrimp, we established awards ranging from US\$ 50.00 to US\$ 500.00 (Fig. 4.5.1). These prizes were awarded every 45 days during major recovery periods. We awarded prizes of US\$ 500, US\$ 200, US\$ 100, and US\$ 50, respectively each time. Winning mark numbers were randomly preselected by computer before the release. If the first chosen mark selected was not recovered, then the second chosen was selected, and so on until four winners were identified. Marked shrimp were returned to personnel located in the major ports. These agents who normally collected catch and fishery effort statistics were given the responsibility of receiving marked shrimp and verifying the recapture area and date.

The generalized movement of white shrimp tagged and released in Caillou Lake are described by Klima (1980). Most of the shrimp migrated westward from the Caillou Estuary release point, although a small contingent did move eastward (Fig. 4.5.2). Movement out of the estuary to the offshore area and then back into other estuaries both near and far from the release point was observed. In 71 days one tagged shrimp migrated into Galveston Bay, a distance of 220 n mi. Several shrimp were recaptured in nearby Vermilion Bay. Some individuals were also observed to move inland from the release point. We believe that we obtained extensive new migration information because we marked and successfully released extremely small shrimp (50 mm total length). Previous to this study, the smallest marked shrimp released in the Gulf of Mexico were usually larger than 80 mm total length (Clark, *et al.*, 1974). A previous study in Louisiana waters (Lindner and Anderson, 1956) showed offshore movement directions similar to those observed in this study, however, long distance migrates were not observed.

The analysis of growth patterns from the recaptured shrimp show striking results. Preliminary growth models fit separately to each group of released shrimp (Fig. 4.5.3) show drastically different growth rates of the individual monthly cohorts.

Growth was very rapid in July, almost as rapid in August, slower in September, and very slow in October. Water temperatures are high in July and decrease thereafter, thus we believe the growth rate is associated with that environmental variable. A temperature-associated asymptotic growth model for white shrimp accounts for 81 percent of the variation between release size (length) and recapture size; whereas time-dependent asymptotic growth models that do not employ temperature data fit to the same data set accounted for but 70 percent of the variation (Phares, MS). A linear growth model was found inadequate and the asymptotic (Richards, Logistic, and von Bertalanffy) models fit the data almost equally well. Preliminary estimates of death rates from several separate experiments indicate that the fishery mortality rate is but a small portion of the total in all months both inshore and offshore.

Instantaneous Weekly Death Rate

	<u>Total</u>	<u>Fishing</u>	<u>Other Causes</u>
Inshore July	.39	.03	.36
August	.39	.09	.30
September	.31	.03	.28
October	.51	.04	.47
Offshore Sept.-Dec.	.29	.01	.27

- Brown Shrimp

During the spring, summer, and fall of 1978, the Galveston Laboratory in cooperation with the Louisiana Department of Fisheries and Wildlife, the Texas Parks and Wildlife, and the Instituto Nacional de Pesca of Mexico initiated a major brown shrimp mark-recapture experiment. The objectives of this experiment were the same as those described previously, and an additional objective was to delineate the stock boundaries in the U.S.-Mexican border area. Experiments were initiated in May in Louisiana and continued throughout the summer and fall. A total of 81 266 shrimp were marked and released in inshore areas and 26 894 in offshore areas (Table 4.5.3 and Fig. 4.5.4). In September U.S. and Mexican biologists aboard the research vessel, OREGON II, marked and released 9 000 shrimp from Brownsville, Texas, to Tampico, Mexico.

Migration information from these experiments indicate that the brown shrimp resource is not composed of isolated stocks, but rather a single population of very mobile adult individuals exists from Tampico, Mexico, to the Mississippi River (Fig. 4.5.5). Adult shrimp released offshore appear to undergo extensive movement both in an easterly and westerly direction. Juvenile shrimp released in the Caillou Lake estuary move offshore and generally westerly, although the majority were recovered close to the release point thus indicating an intensive juvenile fishery immediately adjacent to this estuary.

Shrimp released off Texas moved in a northward direction parallel to the coast toward Galveston and southward toward the Mexican border (Fig. 4.5.6). Three shrimp released off Port Aransas, Texas, migrated across the U.S.-Mexican border. The distribution of recoveries of shrimp released off Port Aransas indicate a significant southward movement toward the Mexican border. Shrimp released off Mexico tended to move northward during the first few months after release with a smaller component moving to the south toward Tampico (Fig. 4.5.7). Four animals released in Mexico migrated into Texas offshore waters. The seven transboundary migrations coupled with the general directed movement from Mexico toward the U.S. border and the movement of brown shrimp released off of Texas southward, toward Mexico show the brown shrimp resource from Corpus Christi to Tampico is indeed transboundary in nature. These results clearly indicate that brown shrimp from Corpus Christi to Tampico should be managed as a single unit and not as two independent separate resources occurring on either side of the border.

Table 4.5.3 Number of Tagged Brown Shrimp Released in 1978 and Number
and Percent Recovered

1978-79 TAGGED SHRIMP STUDY			
<u>BROWN SHRIMP</u>	RELEASE	RECAPTURE	PERCENT
INSHORE			
LOUISIANA	39,086	3,743	9.6
TEXAS	42,180	7	-
OFFSHORE			
LOUISIANA	13,540	463	3.4
TEXAS	4,330	320	7.4
MEXICO	9,024	1,499	16.6
<hr/>			
TOTAL	108,160	6,039	

Since marked shrimp are still being recaptured at this time, modelling of growth and mortality rates have not begun. We expect marked brown shrimp to be returned for two or three years after release.

3. Proposed Programme

The shrimp fishery off of northeast South America is based on four species: pink-spotted shrimp Penaeus brasiliensis, brown shrimp P. subtilis, pink shrimp P. notialis, and white shrimp P. schmitti. White shrimp are found inshore and are of minor importance in the catch. The shrimp fishery operates on a single year-class with very large year-to-year fluctuations in abundance (Jones and Dragovich, 1977). Monthly catch rates peak in March and April and decline gradually thereafter. The catch rates off Brazil are greater than off the Guianas. Juvenile shrimp appear to recruit in March, April, and October from French Guiana, Brazil, and Guyana. The status of the shrimp stocks off of northeastern coast of South America have been investigated and the U.S. National Marine Fisheries Service has been involved in extensive oceangoing surveys; however, a lack of basic information needed for management exists. Such information includes:

- (1) continuous catch and effort statistics
- (2) distributional boundaries of the major stocks, and
- (3) growth and mortality parameters for the major shrimp resources.

We therefore recommend: (1) establishing an accurate and continuing statistical survey to provide catch and effort information for industry and resource managers and (2) initiating mark and recapture studies on recruiting juvenile shrimp to obtain information on migration, growth, and mortality.

Juveniles can evidently be found in the inshore areas off of French Guiana, Guyana, and Brazil during the Spring and Fall months (Jones and Dragovich, 1977). Information generated from marking these juveniles will provide distribution and movement patterns and data on growth rates as well. After some experience has been gained in mark and recapture procedures, specific studies can be successfully carried out to estimate mortality rates. Concurrently, it will be necessary to establish a reliable collection system for catch and effort information and a central data management file. In addition, an adequate incentive system must be established so that marked shrimp will be recovered. Fishermen must be advised of the programme and an adequate incentive system be developed so that recaptured shrimp with appropriate information, as date or recapture and location, will be returned. Since fishermen will not likely immediately become familiar with the programme, study objectives for initial experiments should not be set too high.

It can be expected that shrimps tagged off of one country's coast will be recovered off of another country's coastline. Therefore, a coordinated international programme within the WECAF area is essential. The degree of cooperation will determine the eventual success of the programme and thus the ability of the fishery industry to achieve maximum long-term utilization of the resource. We recommend an international programme be established and that each country be an active participant within this programme.

In summary, we recommend the following efforts be undertaken to construct the necessary data base:

- (1) establish international cooperative infrastructure to conduct mark and recapture experiments with juvenile shrimp in the Spring and Fall to estimate growth rates and migration patterns.
- (2) develop an accurate and continuing survey system to collect and distribute catch and effort statistics, and
- (3) devise and carry out specific studies to estimate mortality rates.

This data can be used to devise models that will predict the status of the resource under various long-term fishing strategies and define methods to achieve maximum long-term utilization of these shrimp resources.

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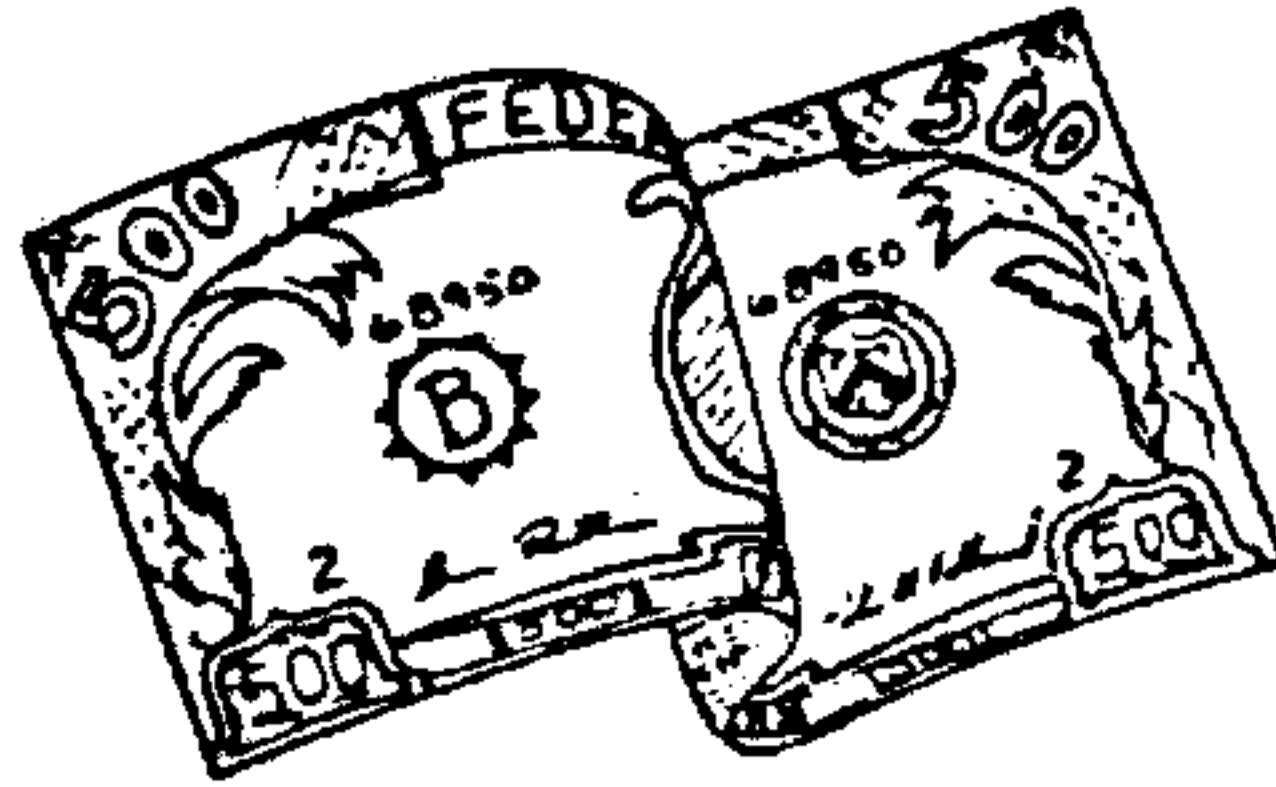
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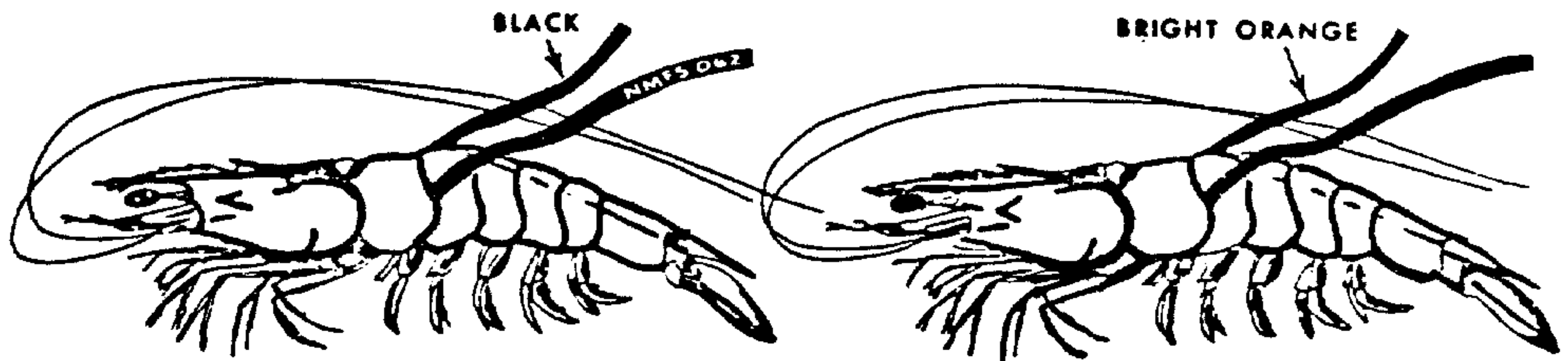
CASH!



AWARDS!

AWARDS FROM \$50.00 TO \$500.00! OUR SHRIMP FISHERY NEEDS YOUR HELP!

SHRIMP HAVE BEEN TAGGED WITH PLASTIC RIBBONS LIKE THIS:



Awards will be randomly selected from tagged shrimp that are returned. To qualify as an entry, the tag must be in the shrimp and the date and location the shrimp was caught must be given. Sets of awards will continue into 1979. Any tag number that hasn't been chosen remains eligible in the later drawings.

AWARDS OF \$500 -- \$200 -- \$100 -- AND \$50
WILL BE AVAILABLE IN EACH SELECTION.

Dates for making awards will be announced.

THIS STUDY IS BEING CARRIED OUT JOINTLY BY THE TEXAS PARKS AND WILDLIFE DEPARTMENT, TEXAS A&M UNIVERSITY, THE NATIONAL MARINE FISHERIES SERVICE AND THE INSTITUTO NACIONAL DE PESCA OF MEXICO.

If you have caught a tagged shrimp or know someone who has please contact:

AGENCY

ADDRESS

PHONE NUMBER

Figure 4.5.1 Poster Advertising Shrimp Incentive System

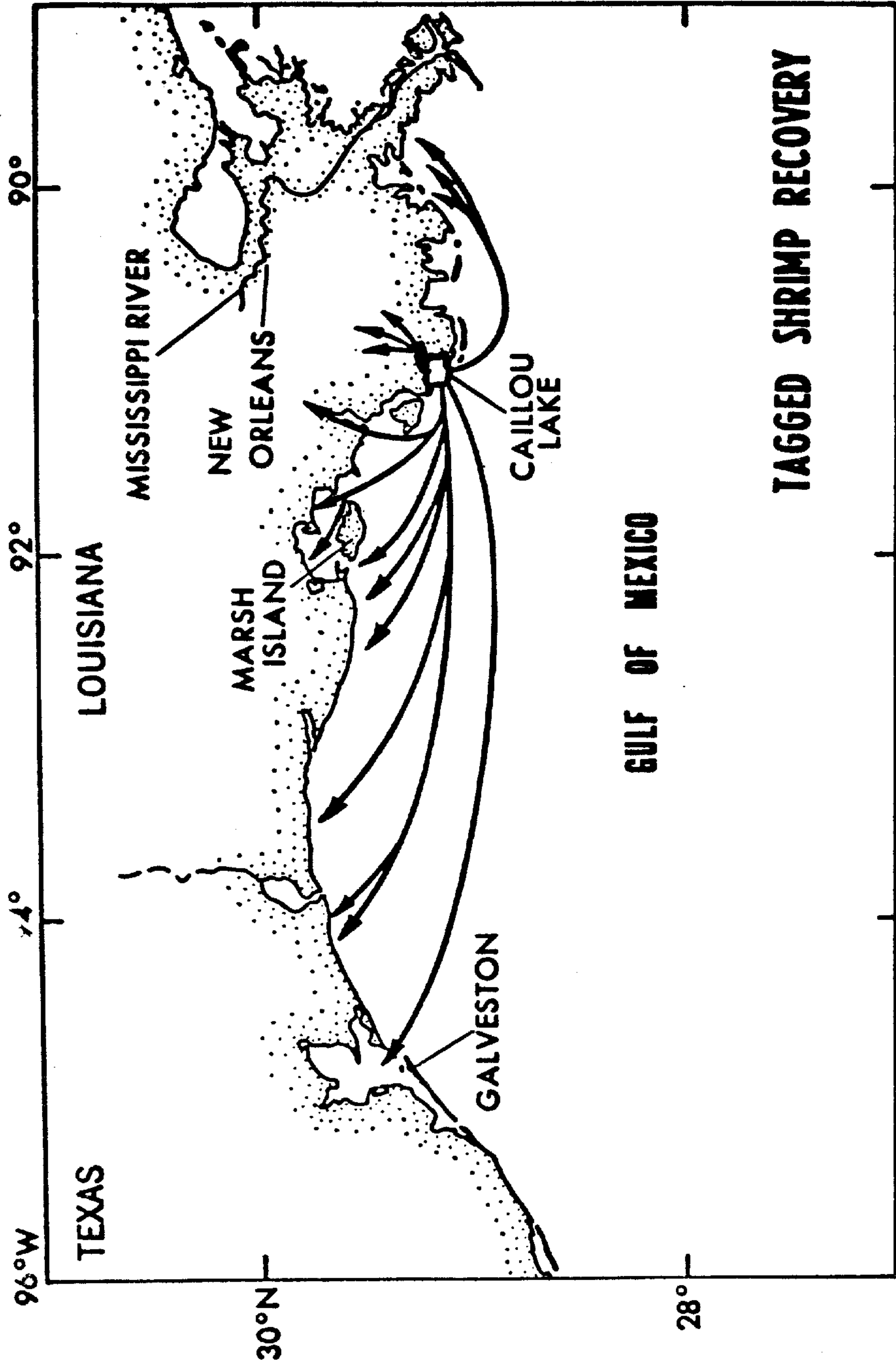


Figure 4.5.2 General Movement Patterns of White Shrimp Released in Caillou Lake, LA from July to October 1977

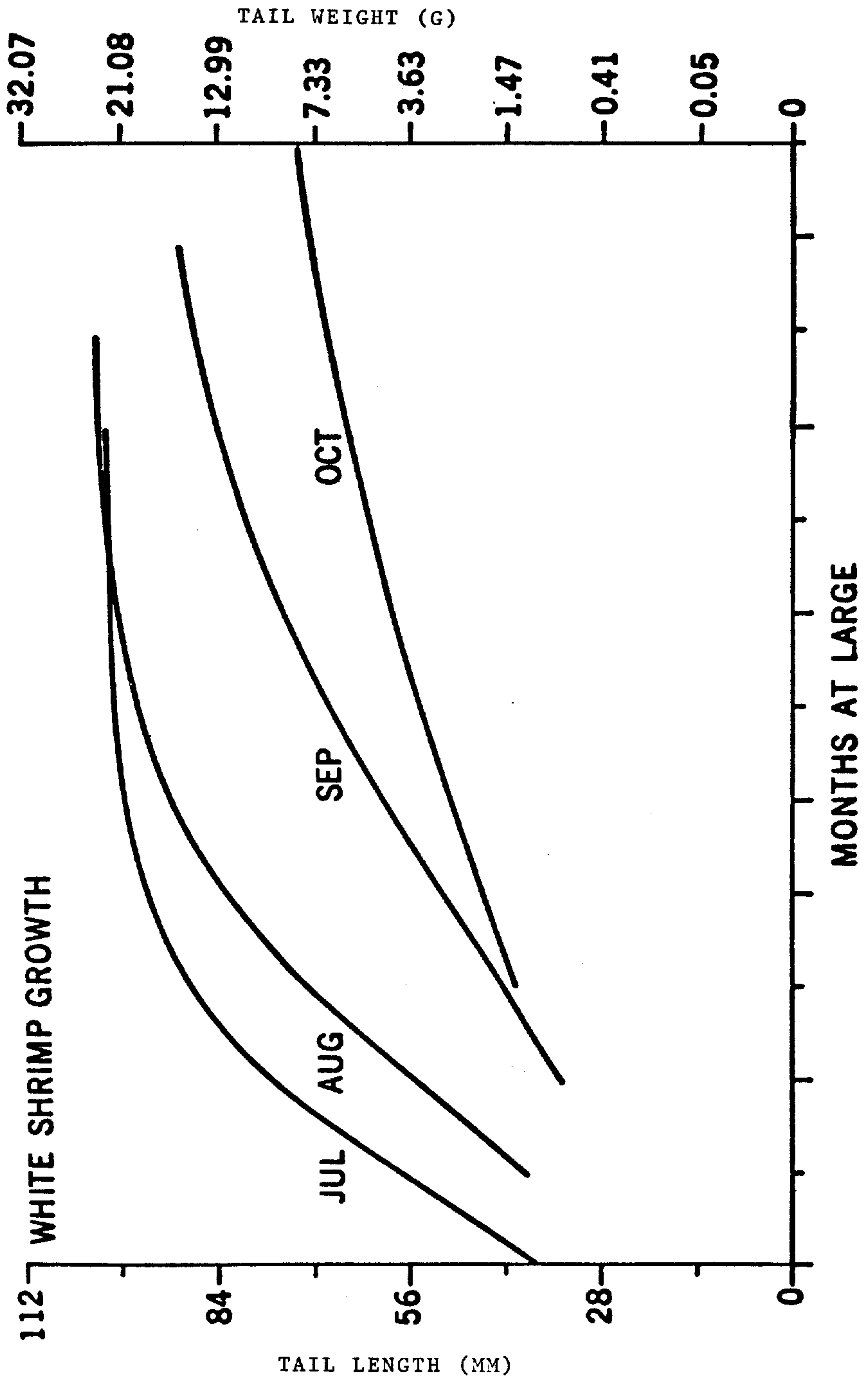


Figure 4.5.3 Comparison of Growth Curves Between July, August, September and October White Shrimp Cohorts

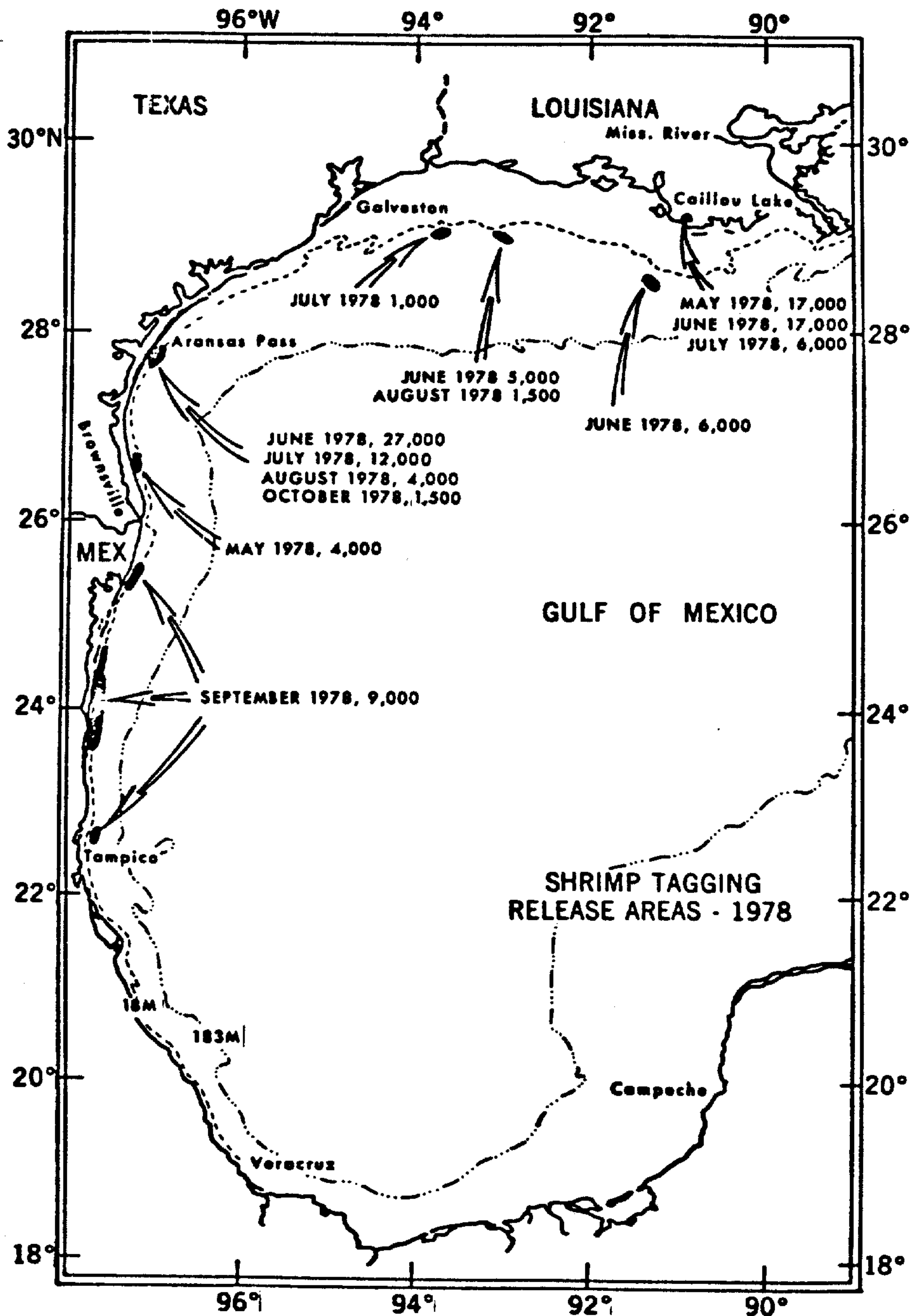


Figure 4.5.4 Location and Numbers of Brown Shrimp Released in 1978 in the Gulf of Mexico

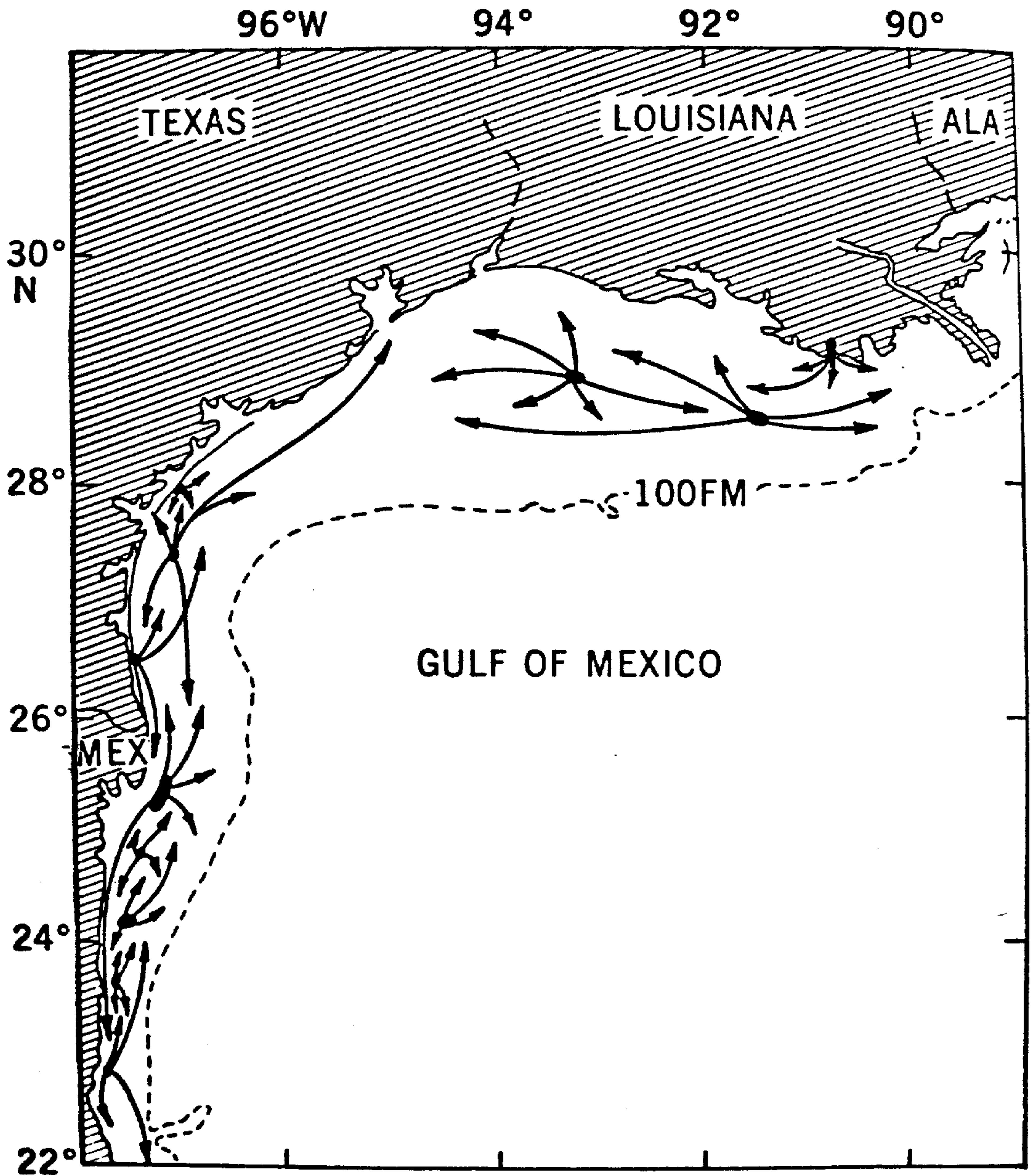


Figure 4.5.5 General Movement Pattern of Brown Shrimp Released in 1978 in the Gulf of Mexico

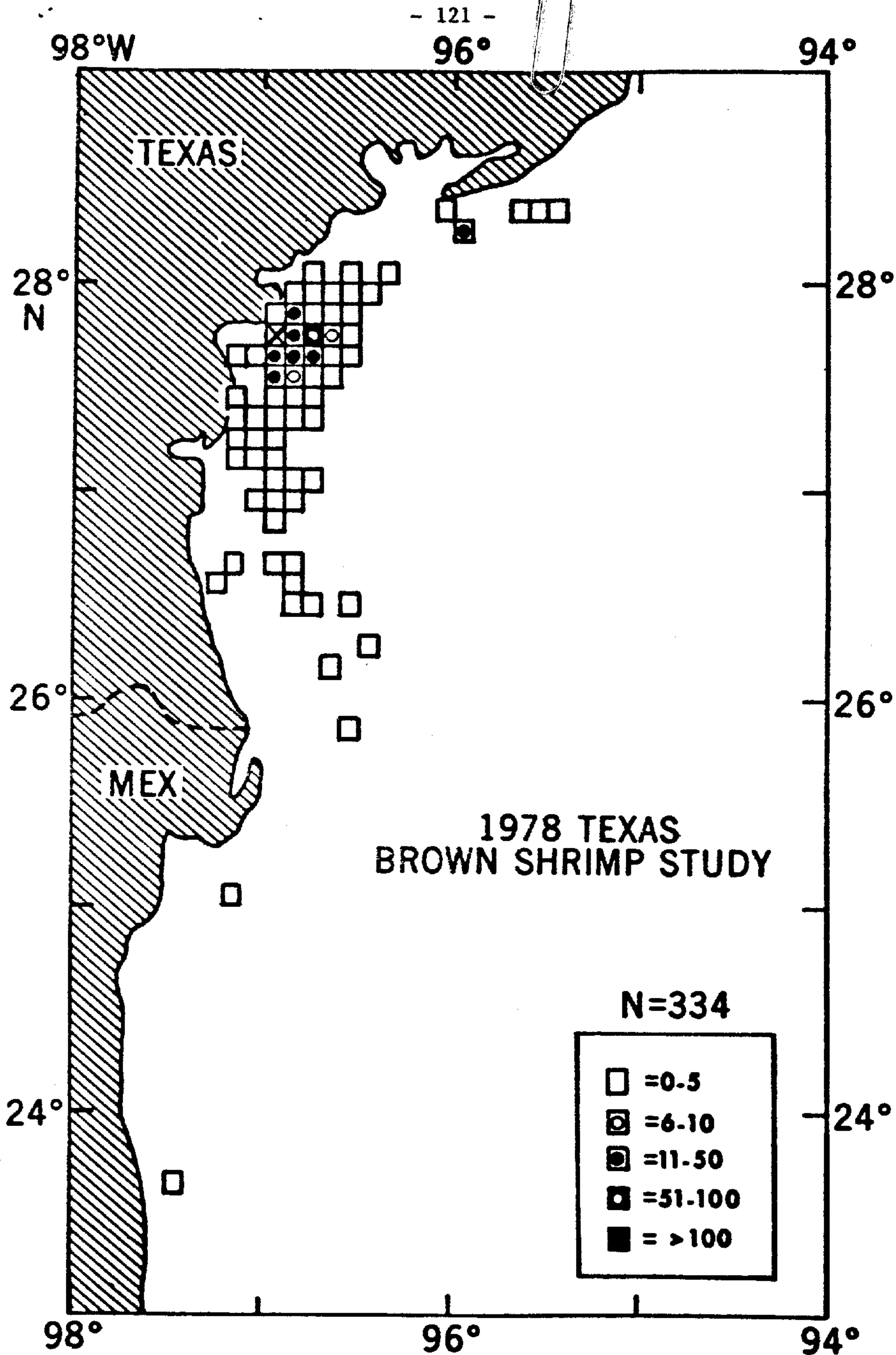


Figure 4.5.6 Density Distribution of Brown Shrimp Recoveries by Six Nautical Square Miles (Texas)

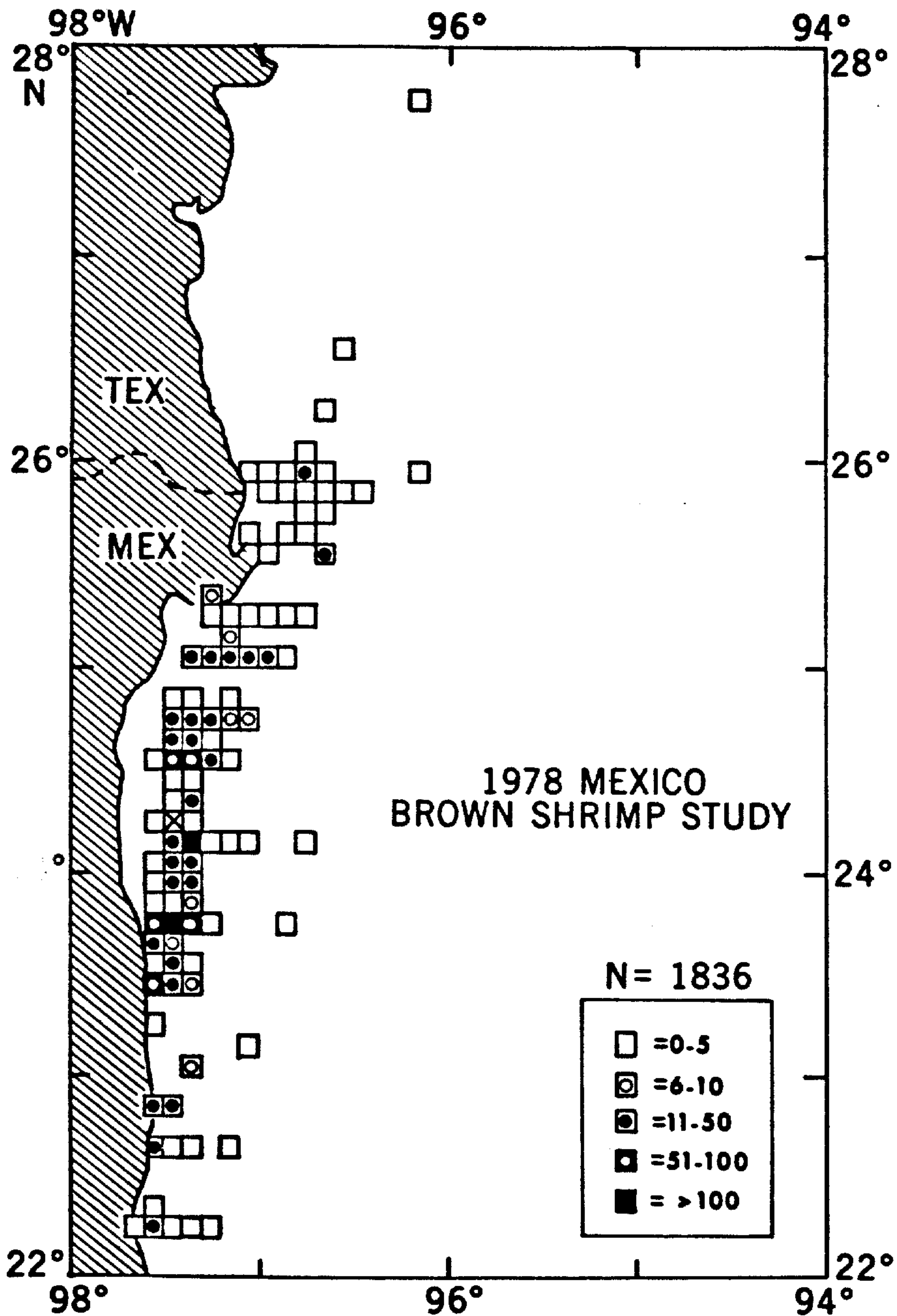


Figure 4.5.7. Distribution of Brown Shrimp Recoveries Off Mexico